Journal of Applied Research on Medicinal and Aromatic Plants xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Applied Research on Medicinal and Aromatic Plants

journal homepage: www.elsevier.com/locate/jarmap

Genetic diversity of *Cucurbita pepo* L. and *Cucurbita moschata* Duchesne accessions using fruit and seed quantitative traits

Reza Darrudi[a], Vahideh Nazeri[a,*], Forouzandeh Soltani[a], Majid Shokrpour[a], Marria Raffaella Ercolano[b]

[a] Department of Horticultural Science, University College of Agriculture and Natural Resources, University of Tehran, Karaj, Iran
[b] Department of Agricultural Sciences, University of Naples 'Federico II', Portici, Italy

ARTICLE INFO

Keywords:
Cucurbita spp.
Fruit traits
Seed traits
Diversity
Cluster analysis
PCA

ABSTRACT

Twenty one accessions of *Cucurbita pepo* and eleven accessions of *Cucurbita moschata* were collected from different regions of Iran and variations in fruit and seed characters evaluated during 2016–2017. The basic statistics of traits has demonstrated considerable variability among accessions. Correlation analysis revealed some important associations among studied traits. In *C. pepo*, a positive correlation were between seed width and fruit weight, seed weight, fruit flesh thickness, fruit cavity diameter and seed length and in *C. moschata*, total soluble solid (TSS) was positively correlated with fruit flesh thickness, fruit weight and fruit yield and negatively correlated with fruit weight/seed weight. PCA generalized 15 quantitative characters to five PCs in *C. pepo* and four PCs in *C. moschata* having Eigen value > 1 explaining 89.85% and 87.13% of the total variability, respectively. Cluster analysis classified *C. pepo* accessions into six and *C. moschata* accessions in five divergent groups. The result showed that in *C. pepo* accessions we can use cluster II members (P02 and P15) as normal seed types and P03 and P05 as naked seed types for next breeding programmes as well as seed production. Among *C. moschata* accessions we suggest M05 and M11 for next breeding programmes and consumption as pumpkin, also we suggest cluster I (M02 and M03) as the best accessions for consumption their fruits as pumpkin.

1. Introduction

Cucurbita pepo L. and *Cucurbita moschata* Duchesne two species of the Cucurbitaceae family, are economically important crops worldwide (Robinson and Decker-Walters, 1997; Loy, 2004). "Styrian oil pumpkin" or *Cucurbita pepo* subsp. *pepo* var. *styriaca* has been formed by an accidental natural mutation. It is the result of a mutation in a single recessive gene and led to a very thin outer hull (naked or hull-less seeds) which highly facilitates the production of this regional specialty oil and also leads to its dark green color (Fruhwirth and Hermetter, 2007). Cucurbits are versatile fruits fleshy shell, seeds, and even their flowers are edible. The immature fruits of various *cucurbita* have been used for culinary purposes in different parts of the world. Pumpkin fruits when riped, can be boiled, baked or steamed (Roberts, 2006). The benefits of *cucurbita* fruits are very important in terms of human health, purification of blood, removal of constipation and are good for digestion and supplying energy (Bisognin, 2002). Raw or roasted pumpkin and squash seeds are used as a snack food for human consumption in many cultures all over the world. The kernels of *cucurbita* seeds have been utilized as flavour enhancers and used in cooking, baking and ground meat formulations as a nutrient supplement and a functional material (Tsaknis et al., 1997; El-Adawy and Taha, 2001). Seed extract has been reported to have antidiabetic, antitumor, antibacterial, anticancer, antimutagenic and antioxidant activities. It has also been found to have strong hypotriglyceridemic and serum cholesterol lowering effects (Fu et al., 2006). The health benefits of *cucurbita* seeds are attributed to their macro and micro constituent compositions. They are a rich natural source of proteins, triterpenes, lignans, phytosterols, polyunsaturated fatty acids, antioxidative phenolic compounds, carotenoids, tocopherol and minerals (Fu et al., 2006). Diversity in plant genetic resources provides opportunity for plant breeders to develop new and improved cultivars with desirable characteristics (Govindaraj et al., 2015) hence determination of the degree of variation of quantitative and qualitative traits present in genetic resources is important for breeding programs (Escribano et al., 1998). Plant breeders can use genetic similarity information to complement phenotypic information in the development of breeding populations (Greene et al., 2004; Balkaya et al., 2010). Iran is the Sixth squash and pumpkin producer (603,629 tons of production in 44,834 ha area in 2014) (FAOSTAT, 2014) but there is no improved cultivar of squash and pumpkin for

* Corresponding author.
E-mail address: nazeri@ut.ac.ir (V. Nazeri).

https://doi.org/10.1016/j.jarmap.2017.11.003
Received 5 May 2017; Received in revised form 3 November 2017; Accepted 14 November 2017
2214-7861/

Please cite this article as: Darrudi, R., Journal of Applied Research on Medicinal and Aromatic Plants (2018), https://doi.org/10.1016/j.jarmap.2017.11.003

Fig. 1. (A) Different types of *C. pepo* seed accessions and (B) Different *C. pepo* and *C. moschata* accessions.

Table 1
Origin of cucurbita accessions used in the analysis.

Accession number	Species	Origin
P01	*C.pepo var. styriaca*	Shahroud, Semnan
P02	*C.pepo var. styriaca*	Khomein, Markazi
P03	*C.pepo var. styriaca*	Shahroud, Semnan
P04	*C.pepo var. styriaca*	Shahroud, Semnan
P05	*C.pepo var. styriaca*	Neyshabour, Khorasan razavi
P06	*C.pepo var. styriaca*	Khomein, Markazi
P07	*C.pepo var. styriaca*	Esfahan, Esfahan
P08	*C.pepo var. styriaca*	Shahroud, Semnan
P09	*C.pepo var. styriaca*	Esfahan, Esfahan
P10	*C. pepo*	Karaj, Alborz
P11	*C. pepo*	Karaj, Alborz
P12	*C. pepo*	Karaj, Alborz
P13	*C. pepo*	Mashhad, Khorasan razavi
P14	*C. pepo*	Marand, East Azerbaijanد
P15	*C. pepo*	Arak, Markazi
P16	*C. pepo*	Marand, East Azerbaijan
P17	*C. pepo*	Qom, Qom
P18	*C. pepo*	Gorgan, Golestan
P19	*C. pepo*	Arak, Markazi
P20	*C. pepo*	Kerman, Kerman
P21	*C. pepo*	Mashhad, Khorasan razavi
M01	*C.moschata*	Karaj, Alborz
M02	*C.moschata*	Neyshabour, Khorasan razavi
M03	*C.moschata*	Neyshabour, Khorasan razavi
M04	*C.moschata*	Rasht, Gilan
M05	*C.moschata*	Gorgan, Golestan
M06	*C.moschata*	Gorgan, Golestan
M07	*C.moschata*	Rasht, Gilan
M08	*C.moschata*	Yazd, Yazd
M09	*C.moschata*	Challus, Mazandaran
M10	*C.moschata*	Karaj, Alborz
M11	*C.moschata*	Behshahr, Mazandaran

growing commercially in Iran and the production of *cucurbita* is based on local accessions and landraces. The landraces are a very important source of genetic diversity, and are an important genetic resource for plant breeders. These landraces may be utilized in a breeding program to increase genetic diversity and to develop useful inbred lines (Geleta et al., 2005; Kasrawi, 1995). Duchesne (1786) and Naudin (1856) concluded that *C. pepo* could be the most polymorphic species in the plant kingdom because of exhibiting the widest variation especially in fruit characteristics. Phenotypic diversity within populations of *cucurbita* is high and includes variation in shape, size and colour of fruits; number and size of seeds; quality, colour and thickness of fruit flesh and precocity in fruit production among other traits (Whitaker and Robinson, 1986; Hernandez et al., 2005). Using mainly fruit shape, Paris (1986) classified edible fruited *C. pepo* into eight cultivar groups: Pumpkin, Zucchini, Cocozelle and Vegetable marrow belong to subsp. *pepo* and Acorn, Crookneck, Scallop, and Straight neck belong to subsp. *ovifera* (Paris 2001). Different researchers have found that genetic diversity within landraces and populations of squash is high including variation in shape, fruit size and colour; seed number and size; quality, colour and thickness of fruit flesh; tolerance to pests; and precocity in fruit production among other traits (Nerson et al., 2000; Ferriol et al., 2003; Paksoy and Aydın, 2004; Hernandez et al., 2005). Balkaya et al. (2010) studied on 40 populations of *C. moschata* and showed a wide diversity of seed characters for example a range of 13.8–24.3 mm for seed length, 7.5–15.3 mm for seed width and 1.6–4.7 mm for seed thickness. Different studies showed the great variation of *C. moschata* using morphological and molecular markers. In some studies, greater genetic diversity was observed in *C. moschata* than in *C. maxima* but comparing *C. moschata* and *C. pepo* varied with the study (Sun et al., 2004; Liu et al., 2004; Du et al., 2011). The genetic diversity in *cucurbita* is probably attributed to the genetic variability of the species for adapting to the diverse agro-ecological conditions and also the variation from crossing between different types is the main cause (Chu et al., 2007). The aim of the present study was to evaluate the genetic diversity and relationships between *cucurbita* accessions and selection of the best accessions from various regions of Iran for seed production, fruit consumption and next breeding programs.

2. Materials and methods

2.1. Plant material and experimental design

This study was conducted at Research Center of Department of Horticultural Sciences, University of Tehran, Karaj, Iran during 2016–2017. Our unpublished experiences on phenotypic variations of these accessions on two growing seasons in this site showed that there isn't any significant variation between years and also we evaluated *cucurbita* accessions variations in this environment because the climate of main areas of pumpkin and squash production in Iran is very similar to this site.The site is at 35°47′ N latitude; 50°56′ E longitude and 1312 m elevation. Long-time average precipitation, temperature and humidity are 390 mm, 14.9 °C and 47% respectively. Total annual precipitation was 417 mm in summer 2016. Soil characteristics were including: Soil Texture = clay loam, pH value = 8, Electrical conductivity = 1.31 ds/m, organic matters = 0.94%, available K_2O = 256 mg/kg, available P_2O_5 = 84.5 mg/kg, total nitrogen = 0.1% and $CaCO_3$ = 6.7%. Sowing and harvesting were performed on May 10 and the first week of September respectively and seeding was carried out directly in the field. A collection comprising 21 accessions of *C. pepo* including nine naked seed types (Styrian oil pumpkin) which have been imported to Iran in atleast 15 years ago and 12 normal seed types and a collection comprising 11 accessions of *C. moschata* which all accessions have been cultivating in various regions of Iran were chosen in spring 2016 for this study (Fig. 1 and Table 1). Evaluation for each species was performed separately based on a randomized complete blocks design (RCBD) with three replications and